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Beta decay of ^{132}Cd: exploring the puzzle of decay half-lives southeast of ^{132}Sn

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The region of nuclei around doubly magic ^{132}Sn [1] offers a unique window to study nuclear structure. Collective effects such as deformation quickly come into place a few proton numbers above tin [2]. On the other side of the Z=50 line, nuclei with proton number below Sn, such as Cd and Pd, are typically treated to be good shell model nuclei [3,4]. These calculations are in turn used to provide for nuclear parameters in models of isotope productions in stellar rapid neutron capture (r-process) [5]. However, recent measurements of the decay half-lives in the region show systematic discrepancies with shell model calculations. These discrepancies account for the majority of the deviations of calculated rprocess yields with solar abundances around the A~130 peak [6]

In order to investigate the origin of the large discrepancies in beta-decay half-lives, the beta decay of Z=48, N=84 ^{132}Cd was studied at the ISOLDE facility, CERN. The large majority of the beta-decay strength was expected to populate the unbound lowest-energy 1^+ state through a Gamow-Teller transformation of a $g_{7/2}$ neutron into a $g_{9/2}$ proton [3,4], resulting in a (observed [7]) large neutron emission probability. In order to identify this state, the neutron time-of-flight array VANDLE [8,9] was installed at the ISOLDE decay station. The setup consisted in 26 VANDLE bars, for a 5% detection efficiency at 1 MeV, as well as 4 HPGe clovers, 3% efficiency at 1 MeV. We observed none of the gamma lines previously observed in 132In in the decay of ^{133}Cd [10], nor any other gamma line that could be assigned to be in ^{132}In, suggesting a neutron branching ration close to 100%. Large Gamow-Teller strength was observed in the neutron time-of-flight spectra, as evidenced by 2/3 of the neutron intensity being emitted at 2 MeV. Analysis of the data indicates the Gamow-Teller strength occurs through 4 transitions to 4 individual 1^+ states in ^{132}In. The presence of multiple competing states, fragmenting the overall strength, offers a compelling explanation for the experimental half-life of ^{132}Cd being longer than state-of-the-art calculations [3]. The fragmentation of the 1^+ strength will be discussed in the framework of shell model and ab initio calculations using neutron-hole excitations of the ^{132}Sn core.

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